farther and farther from zero as the fall becomes heavier. Experience alone will show whether that is, or is not, superior to moving it one step for each $\frac{1}{100}$ of an inch of fallen rain, which can be done by making a Crosley rain gage send a circuit into the room where the brontometer is placed, and strike a bell there. In a heavy storm there will, however, be so much for the observer to do that very probably count would be lost. It may, therefore, be necessary to make it act automatically.

The fourth pen is actuated somewhat like a piano. On the occurrence of a flash of lightning the observer presses a key, the pen travels slightly to the right and flies back to zero. Referred to the automatic time scale this gives, to a second, the time at which the key was depressed.

The fifth pen is similar, but being intended to record the thunder, the observer will continue to hold down the key until the roll is inaudible. The time of the departure of this pen from zero will evidently be later than that for the lightning by the time interval due to the distance of the flash, and possibly something may be learned from the accurate record of the duration of the thunder.

The sixth pen is similar to the third, and is intended to record the time, duration, and intensity of hail.

The seventh and last pen is devoted to an automatic record of atmospheric pressure. As the rapid motion of the paper, which is indispensable for studying the details of a thunderstorm, has enlarged the time scale more than a hundredfold, it was imperative that the barometric scale should itself be greatly enlarged. But the range of the barometer in London is more than $2\frac{1}{2}$ inches, and no enlargement less than ten times the natural (mercurial) scale would be of any use; hence a breadth of 25 inches of paper would be necessary unless some mode of shifting the indication could be devised.

Several plans were tried but finally a modification of Richard's statoscope has been adopted, which is so sensitive that it will indicate the opening or shutting of a door in any part of the house, gives a scale of 30 inches for each mercurial inch (i. e., about three times that of a glycerine barometer) and yet only requires 4 inches breadth of the brontometer paper. Without entering into all the details of construction, it is desirable to explain the general principle and its application. As it was essential that the apparatus should record accurately to 0.001 inch of mercurial barometric pressure, it was evident that friction had to be reduced to a minimum, and considerable motive power provided. This is done by placing in the base of the brontometer a galvanized-iron chamber which contains about $3\frac{1}{2}$ cubic feet of air; on the upper part are a series of elastic chambers, similar to the vacuum boxes of the aneroid barometers but much larger.

When the instrument is to be put in action these chambers are connected with the large air chamber, and a tap is closed which shuts off communication with the external air. Any subsequent increase or decrease of atmospheric pressure will compress or allow to dilate the air in these chambers, and the motion of the elastic ones produces that of the recording pen.

Obviously, any large change in the temperature of the confined air would vitiate the readings; but (1) the instrument is not required to give absolute, but merely differential, values, and (2) the influence of the changes of temperature is greatly reduced by the chamber being surrounded with 4 inches thick of nonconducting material, besides nearly 1 inch of wood outside of it. The change of temperature in a room, and during the short time that the statoscope will be worked without resetting to zero (i. e., without opening the tap) has not hitherto produced any measurable effect.

The author hopes, in a subsequent paper, to have the honor of laying before the society the results obtained from this novel apparatus.

APPENDIX.

List of some papers and memoirs on the subject of the paper.

Planer, J. J. Observationis Oscillationis Mercurii in Tubo Torricelliano Erfordiæ instituta. Acta Acad. Moguntinæ. 1782–3.

Rosenthal, G. E. Merkmale für das Herannahen d. Gewitter. Mag. Neueste Physik. Vol. 4. Part I. 1786.

Toaldo, G. Dei moti del Barometro nei Temporali. Giornale Astro-Meteorologico. 1794. (The note is dated April 3, 1795; see also his collected works—Completa Racolta, etc. Venezia. 4 vols. 8vo. 1802. Vol. 3. P. 104, and vol. 4, p. 41).

Frenzel, F. C. Veränderung d. Barometerstandes bei Gewittern. Gren's Neues Journal der Physik. Vol. 4. 1797. P. 250.

Gronau, K. L. Ueber die Gewitter in den Gegenden von Berlin. Schweigger's Journal. Vol. 31. 1821. P. 128.

Strehlke, F. Ueber d. Einfluss d. Gewitter auf den Barometerstand. Poggendorff's Annalen. Vol. 19. 1830. P. 148.

Kaemtz, L. F. Lehrbuch der Meteorologie. Vol. 1. 1831. P. 351.

Johnson, M. J. On the Detection and Measurement of Atmospheric Electricity by the Photo-barograph and Thermograph. British Association Report. 1855. Part II. P. 40.

—— Meteorological Observations made at the Radcliffe Observatory. Oxford. 1857. P. 34.

Goullon. Élévation brusque du Baromètre pendant un Coup de Tonnerre. Bulletin International. Mars 21. 1866.

Whitehouse, W. On a New Instrument for Recording Minute Variations of Atmospheric Pressure. Roy. Soc. Proc. Vol. 19. 1871. P. 491.

Abercromby, Hon. R. On the Barometric Fluctuations in Squalls and Thunderstorms. Meteor. Soc. Quart. Journ. Vol. 2. 1875. P. 450.

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Mascart, E. Sur l'Inscription des Phénomènes Météorologiques, en particulier de l'Électricitè et de la Pression. Journal de Physique. Vol. 8. 1879. P. 329. Annuaire de la Société Météorologique de France. Vol. 28. 1879. P. 7.

Schenzl, G. Ungewitter vom 23 Februar, 1879. Zeit. d. Oesterr. Gesells. f. Meteor. Vol. 14. 1879. P. 146.

Renou, E. [Diagrams only.] Annales du Bureau Central Météor. 1880. Part I.

Fines. Climatologie du Rousillon. Annales du Bureau Central Météorologique. 1881. Part I. B. 118.

Assmann. [Interesting reproductions of the Magdeburg barograph curves are given in the] Jahrb. der Meteor. Beob. der Wetterwarte der Magdeburgischen Zeitung. Jahr. 1—5, Magdeburg, 1883–87.

Koeppen Ueber Barometerschwankungen beim Gewitter. Tageblatt der 57 Naturforscherversammlung zu Magdeburg. 1884. P. 301.

Hellmann, G Eine historische Bemerkung. Zeits. d. Oesterr. Gesells. f. Meteor. Vol. 19. 1884. P. 43.

Bezold, W. von. Ueber die Vertheilung des Luftdruckes und der Temperatur während grösserer Gewitter. Zeits. d. Oesterr. Gesells. f. Meteor. Vol. 19. 1884. P. 281.

Schoenrock, A. Ueber Kleine unregelmässige Schwankungen des Luftdruckes nach den Aufzeichnungen des Barographen. Zeits. d. Oesterr. Gesells. f. Meteor. Vol. 19. 1884. P. 396.

Ferrari, C. Ueber die Vertheilung des Luftdruckes und der Temperatur bei Gewittern. Zeits. d. Oesterr. Gesells. f. Meteor. Vol. 19. 1884. P. 426.

—— Andamento tipico dei Registratori durante un Temporale. Annali Meteorologia Italiana. Vol. 7. 1885. Part I. P. 65.

—— Ueber die Krümmung der Barometer-curve während des Gewitters. Das Wetter. Vol. I. 1885. P. 135.

Schoenrock, A. Ueber kleine unregelmässige Barometer-Schwankungen. Wild's Repertorium. Vol. 9. 1885. No. 8.

Klossovsky, A. Les Orages en Russie. Odessa. 1886.

Boernstein, R. Die Gewitter vom 13–17 Juli, 1884, in Deutschland. Zeits. f. Meteor. Vol. 22. 1887. P. 443.

Less, E Ueber kurze Luftdruckschwankungen, welche in Begleitung stärker Blitzschläge auftreten. Zeits. f. Meteor. Vol. 23. 1888. P. 151.

Descroix, L. Phénomènes accidentels * * * à Montsouri en 1888. Annales de l'Observatoire de Montsouris pour 1889. P. 195.

Ferrel, W. A Popular Treatise on the Winds. 1889.

COLORED SNOW.

A correspondent in Pawpaw, Mich., asks:

Has any one ever investigated the cause of colored snow? Almost every winter we have snowfalls that have a powdery substance that would be almost imperceptible except that it colors the snow quite materially. We had such a phenomenon last Saturday (February 16, 1901). Three years ago a very pronounced black snowfall occurred. I melted a quantity of the snow; the residue was in scaly particles, and, so far as my amateur investigation could determine, it was entirely metallic. I have some of the material from last Saturday's snowfall. It is brown instead of black, but is not yet entirely dry. It has the appearance of being vegetable matter, although the day was so calm that my windmill did not run. We used to call it prairie dust, swept off the western plains, but I am inclined to the belief that it is meteoric—star dust, if you please.

It would be interesting to know the extent of this colored snowfall, and your department, it would seem to me, is the proper one to investigate it.

This phenomenon is not an unusual one, but since none of the numerous voluntary observers in Michigan noted colored snowfall on February 16, 1901, we infer that in this case the fall was confined to a small area, perhaps embracing only two or three townships.

In the New York State Weather Service Report for April, 1889, (see also the Monthly Weather Review, Vol. XVII, April 1889, p. 89,) is an account of a black snowfall "covering the counties of Lewis, northern Herkimer, southern Franklin, and the northwestern part of Essex, and probably Hamilton." The sediment consisted principally of finely divided earth or vegetable mold, and no doubt closely resembled that collected by our correspondent at Pawpaw, Mich., on February 16, last.

Colored snow has been observed from very early times. In the American Almanac for 1833, p. 65, is a translation from Pouillet's Meteorologie of 1828 which credits Pliny (Book IX, chap. 35) with the statement that snow becomes red with age, and Mr. Francis Bauer with the discovery that the red color of the snow is due to the growth of "little mushrooms of the genus *uredo*, forming a peculiar species which he calls *uredo nivalis*, because snow is their natural soil."

In the American Journal of Science and Arts for 1841, vol. 41, p. 64, is a synopsis of a communication by Prof. Louis Agassiz on *animals found in red snow*. "He stated that Shuttleworth had lately demonstrated that besides the *Protococcus nivalis*, the red snow contained several species of *infusoria*. The results of Professor Agassiz's observations led him to conclude that the red snow was altogether an animal production, and that the so-called *Protococcus nivalis* is the ova of a species of rotiferous animal called by Ehrenberg *Philodina roseola*. This animalculae he had found dead in the red snow, and abundantly in the ditches in the neighborhood, at the bottom of which its ova produced a red deposit. Under the microscope the colored ova in the ovaries could be distinctly observed. He has also seen the infusoria described by Shuttleworth."

From the same journal for 1852, 2d series, Vol. XIII, p. 442, we quote the following: "Observations on a red snow which fell in Switzerland on the 3d and 4th of February;" by M. Ehrenberg. (Monatsber. Berlin Acad., March 6:)

> This red snow covered a large extent of country, including the cantons and districts of Zurich, Berne, Schwyz, Lugano, Bergamo, and Milan. It afforded a red precipitate, which yielded on analysis a large quantity of lime and silica, a little alumina, and some iron and magnesia. Microscopically examined, it was found by Ehrenberg to contain sixty-three organic forms, allied to those heretofore found by him in atmospheric dust, without any marine species.

In his American Weather, p. 74, Gen. A. W. Greely has the following to say of Arctic snows:

> Green and red snow are to be found in a few parts of the world, principally in the Arctic regions, the color being due to minute organisms called *Protococcus nivalis*. The most extensive deposits of red snow known, situated near Cape York, Greenland, were discovered by Capt. John Ross, R. N., in 1818, from whom the hills, owing to this snow, received the fanciful name of Crimson Cliffs. The color, however, as seen by the author, is a faint, dirty, dull red, and not crimson.

The MONTHLY WEATHER REVIEW for March, 1879, p. 16, states that—

> A microscopic examination of the yellow snow which fell at South Bethlehem, Pa,, on the 16th of that month disclosed the fact that the color was due to the presence of the pollen of pine trees that were then in bloom throughout the States farther south.

An extensive investigation of the black snow of January, 1895, will be found in the MONTHLY WEATHER REVIEW for that month (Vol. XXIII, pp. 15–19), wherein it is shown that the black or brown snow was colored by the fine soil blown along on the gales that accompanied the storm.

In the same journal for August, 1901, p. 374, it has been shown that the autumn haze is undoubtedly due to the finest dust—

> Composed of one or all of the following substances, namely, fine particles of soil or the dead leaves of plants, or ashes from wood fires, salt from the ocean spray, the shells or scales from microscopic silicious diatoms, germs of fungi, spores of ferns, pollen of flowers, etc.

Aqueous vapor utilizes these minute dust particles as nuclei about which to condense, but they would of themselves hardly be sufficient to explain the dark color of the snowflakes. If, however, after the snowflakes had formed they fell through or with a cloud of dust, smoke, pollen, or any other powdery substance, the powder would no doubt settle with them and impart its own peculiar color to the fallen snow.

It thus appears that the colored snowfalls occasionally noted are to be attributed, not to meteoric dust, but to dust taken up into the air from the surface of our own planet. There is only one case fairly well established where the snow was darkened by dust (iron) that had come from outside the atmosphere. The minute organisms that sometimes impart color to the snow, and particularly in Arctic regions, require time for their development, and we would hardly expect them to be numerous in newly-fallen snow, although they undoubtedly multiply with great rapidity.—*H. H. K.*

ELECTRICAL PHENOMENA; INCANDESCENT CLOUDS.

In a letter dated Braidentown, Fla., August 28, 1901, Mr. H. H. Ten Broeck sends the following account of electrical phenomena observed by him:

> About 9 p. m. of May 30, 1901, I saw some clouds pulsating with light like that of an aurora. They were small and very thin, showing stars through them, and drifting slowly eastward, overhead. On turning from them for a few moments and looking at them again, I was surprised to find them almost invisible. In a few moments they became plainer, and I saw they were lambent like the streamers of an aurora. I watched them for several minutes, during which they varied in light about every fifteen seconds. I then noted a larger, much denser cloud about west-northwest 20°, which showed the same action of auroral light. A bank of clouds covered the whole northern sky to some 20° above the horizon; they were very bright, but showed no variation in their light. A few scattered clouds in the south also were free from variation. There was nowhere any trace of streamers. A violent storm followed the next night, which in eighteen hours discharged nearly 7 inches of rain, a very unusual amount for the time of year. I have nowhere seen its equal in nine years.
>
> I have also noted more lightning without thunder. I reported some instances a few months ago in the MONTHLY WEATHER REVIEW. I saw a flash recently going from one cloud to another. It was about two miles long and very bright. I expected a violent clap of thunder, but none came. I have often seen such discharges followed by loud thunder which sometimes lasts over a minute before it dies away.

The preceding observations by Mr. Ten Broeck seem especially interesting because they harmonize with several similar experiences by the Editor. Any one may frequently observe, at night during a storm, clouds floating along and becoming now bright and now dark—the different parts of the same cloud may be bright and dark alternately. It will be easy to perceive thereby that this cloud light is not reflected from terrestrial sources. There seems but one explanation: the cloud is under the influence of an electrical discharge and is rendered luminous by it. Either the cloud particles are incandescent, as in the ordinary incandescent electric light, or the air between the particles is incandescent, as in intense lightning and the ordinary arc lights; in either case we may speak of an *incandescent cloud*, as distinguished from the "phosphorescent," "iridescent," "fluorescent," "luminescent" clouds that have been observed very high in the atmosphere and which apparently become luminous by reflecting distant twilight.

Of the above four terms applied to these clouds, phosphorescent best describes the pure soft, pearly white tint, but for fear lest some may imagine that the presence and oxidation of phosphorous causes the light, the Editor prefers to use the term "pearly" cloud.

Now the incandescent cloud is certainly a true case of incandescence and merits spectroscopic study. It is also a step or phase in the series of phenomena that includes the aurora and the lightning, and, therefore, ought to be recorded by every voluntary observer. As the Editor has often shown, an auroral region is generally surrounded by regions in which